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ABSTRACT

In anticipation of House Bill 246 (now Texas Administrative Code Chapter 75) which requires an inquiry-based, process-approach to the teaching of science, the Richardson Independent School District established the Elementary Science Pilot Project and adopted the Science Curriculum Improvement Study (SCIS) as part of their new K-6 Science through Discovery curriculum. This paper reports on a study which attempted to assess and analyze the attitudes toward science of teachers and students in SCIS classes as compared to teachers and students in non-SCIS classes. A post-test-only control group design was used for this study. The Preferences and Understandings instruments (student and teacher versions) were administered; these instruments are attitudinal measures whose items are referenced from the 1977 Third Assessment of Science of the National Assessment of Educational Progress (NAEP). It was found that SCIS and non-SCIS teachers share similar attitudes toward science. After experiencing one year of an inquiry-oriented, process-approach science curriculum, highly significant attitudinal differences toward science and science classes were observed between SCIS and non-SCIS students. (TW)

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AN IMPLEMENTATION STUDY:

AN ANALYSIS OF ELEMENTARY STUDENT AND TEACHER ATTITUDES TOWARD SCIENCE IN PROCESS-APPROACH VS. TRADITIONAL SCIENCE CLASSES

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ABSTRACT

In anticipation of House Bill 246 (now Texas Administrative Code Chapter 75) which requires an inquiry-oriented, process-approach to the teaching of science, the Richardson Independent School District established the Elementary Science Pilot Project and adopted the Science Curriculum Improvement Study (SCIIS) as part of their new K-6 Science Through Discovery curriculum. This study assesses and analyzes the attitudes toward science of teachers and students in SCIIS classes compared to teachers and students in non-SCIIS classes. SCIIS and non-SCIIS teachers share similar attitudes toward science. After experiencing only one year of an inquiry-oriented, process-approach science curriculum, drastic attitudinal differences toward science and science classes were observed between SCIIS and non-SCIIS students.

BACKGROUND

During the past ten years, it has become popular to discard the science programs developed during the 1960's and early 1970's. Critics of these programs maintain that students did not acquire science concepts and that basics needed to be stressed over process skills. Critics also claimed that the advent of the 1960's curricula led to the development of better "inquiry-oriented" science textbook series with a balance between content and process. Throughout the debate, the status of elementary science education has steadily declined. It has been reported that:

1. Science education is being displaced by an emphasis on "basic skills" (Stake and Easley, 1978).
2. "If there were such a thing as an 'endangered subjects' list, science would qualify for emergency help and protection" (Rowe, 1980, p. 19).
3. "The amount, if not the quality, of science teaching is declining" (Manning, Esler, and Baird, 1982, p. 40).

Cries for revitalizing the science and technology education in the United States are again being heard -- the cries are perhaps even more obstreperous than in 1957. Science teachers, science coordinators, school administrators, as well as the public in general, are beginning to realize that the nation that dramatically led the world into the age of technology is failing to provide its children with the intellectual skills necessary for the 21st century. There is a realization that we indeed must return to the basics, but that the "basics" of the 21st century are not only reading, writing, and arithmetic. The "new basics" must include communication and higher problem solving skills, as well as scientific and technological literacy -- the thinking tools that will allow our children to understand the technological world around us (National Science Board, 1983).

Chapter 75 has revitalized science education in Texas by redefining the scope, sequence and nature of the science to be taught. Science must be taught as a process. Time requirements have also been established: in grades 1 through 3 a minimum of 100 minutes per week is required, while in grades 4 through 6 a minimum of 45 minutes per day is required. In accordance with the State Board of Education Rules for Curriculum, each grade "shall have an equal balance of content and activities from the life, earth, and physical sciences and shall include the following essential elements" (Texas Education Agency, 1984):

	Essential Element	Applicable Grades
1.	Manipulative laboratory skills.	K-6
2.	The use of skills in acquiring data through the senses.	K-6
3.	The use of classification skills in ordering and sequencing data.	K-6

4.	Experience in oral and written communication of data in appropriate form.	K-6
5.	Experience in concepts and skills of measurement using relationships to standards.	1-6
6.	The use of skills in drawing logical inferences, predicting outcomes, and forming generalized statements.	2-6
7.	Experience in skills in relating objects and events to other objects and events.	4-6
8.	Experience in applying defined terms based upon observations.	4-6
9.	Experience in identifying and manipulating the conditions of investigations.	5-6

Each essential element is delineated further by specific grade level descriptors which cite representative concepts, skills, and/or processes to be acquired. Thus, the state has identified the "essential elements" for each grade and it is the local districts responsibility to articulate a sound process-approach science curriculum.

RATIONALE

In anticipation of Chapter 75, the Richardson Independent School District conducted audits during the 1982-83 academic year to assess the status of science education in the district. In general, it was found that the process-approach was not in wide usage by elementary teachers. In response to those data, the Elementary Science Pilot Project was established. The Science Curriculum Improvement Study (SCIIS) was adopted as part of the districts new K-6 Science Through Discovery curriculum. The overall goal of the Elementary Science Pilot Project is to implement a science curriculum that emphasizes inquiry-oriented, process-approach science. Concomitant goals are to enhance teacher attitudes toward science and to broaden teacher knowledge so that curriculum development efforts will be relevant.

The overall implementation plan will take five years. During the first year, 1983-84, SCIIS was introduced into six of the 35 elementary schools in the district. SCIIS was phased into eight additional schools during the 1984-85 academic year, with the remaining 21 schools scheduled for implementation in 1985-86. Beginning in the third year, and following a similar phase-in process, the SCIIS curriculum will be modified to emphasize the application of scientific concepts to students' daily lives with a focus on science, technology and societal issues in accordance with the science education goals for the 1980's and beyond.

The major objective for 1983-84 was to assess the effectiveness of the program by comparing SCIIS student and teacher attitudes toward science to those of students and teachers in non-SCIIS classes. A number of recent research syntheses have established the superiority of process science over traditional science (e.g., Bredderman, 1983; Shymansky, Kyle, and Alport, 1983; Weinstein, Boulanger, and Walberg, 1982). These syntheses, however, did not include modern textbooks series which have been developed since the curriculum development era. Many new textbook series purport to be "better" than the 1960's curricula primarily due to the influence of those projects. This study will provide preliminary information regarding the effectiveness of a 1960's curriculum when compared to a modern textbook series; as well as assessing the relevance of such curricular programs when they form the basis for curricular revision in the 1980's.

PURPOSE

Two questions provide a focus for the results presented in this study:

1. How do the attitudes toward science of students who have completed one year of SCIIS compare to the attitudes of students in non-SCIIS classes?

2. How do the attitudes toward science of teachers who have received inservicing and who have taught one year of SCIIS compare to the attitudes of teachers who teach non-SCIIS classes and who have not received any science inservicing?

It is anticipated that the results of this assessment will provide valuable information regarding the attitudes of teachers and students toward science and the teaching of science, as well as identifying specific needs that teachers might have regarding the teaching of inquiry-oriented, process-approach science. Such information will enable districts to focus future inservice and implementation efforts on areas of interest and/or concern to teachers and students.

IMPLEMENTATION SUPPORT

The district has funded extensive inservice education for teachers and principals, as well as provided administrative support and services. Administrative support includes a SCIIS Coordinator in addition to a K-12 Science Consultant. The coordinator assumes responsibility for centralized ordering of materials and supplies, inservice planning and operations, curriculum writing and management, budgeting, and problem solving for individual teachers. Local curriculum writing and continuous evaluation of the implementation process reflect efforts to establish and maintain the dynamic nature of the program. The district has funded a Living Materials Center to provide live organisms for classroom investigation; has established a related projects fund to purchase microscopes, other equipment, and related software;

and, has correlated support services throughout the district with the new science scope and sequence. Thus, outdoor investigations at the Environmental Studies Center, inquiry lessons at the Planetarium, and audiovisual materials and books in the Television and Media Center and building libraries are all integral components of the Science Through Discovery curriculum. Finally, a sixth grade science specialist has been identified in each building to assist with the total implementation.

The most important component of the process is the inservice education which teachers and principals receive. The overall goal of such inservicing is to provide everyone associated with the curriculum with an understanding of the nature of inquiry-oriented, process-approach science. There are five primary components to the inservice provided new SCIIS teachers and principals. (1) A spring orientation meeting introduces principals to the new science program, the philosophy and instructional strategies associated with process-approach science, as well as their responsibilities as an instructional leader. Administrators already engaged with the implementation process are present in order to answer questions to support the importance of the project to the district. (2) In early August, new SCIIS teachers receive two days of inservice education. Teachers view slides and videotapes regarding the program and the administrative support they can expect to receive. They also attend grade level sessions led by master SCIIS teachers where they experience each physical science lesson. These workshops also focus on key instructional concerns such as: teaching without a textbook; using outside resources in the classroom; evaluating and assessing student performance; classroom management; and, the use and care of equipment and organisms in the science classroom. During the August meetings, building principals attend additional program

evaluation sessions and are encouraged to attend various grade level sessions. (3) In October, grade level representatives from each building attend grade level meetings to discuss implementation programs and concerns. Experienced SCIIS teachers are present to answer questions; provide guidance, reassurance, and ideas; as well as to broaden the perspective of beginning teachers regarding the teaching of process-approach science. (4) Prior to the second semester, a one-day inservice workshop is provided for all new SCIIS teachers focusing on the life science component of the curriculum. (5) Finally, a graduate course is offered each summer to provide teachers with science content and instructional strategy updating, as well as affording teachers the opportunity to develop curricular materials identified as essential components of the total Science Through Discovery scope and sequence. Over 10% of all elementary teachers in the district attended the 1985 summer workshop entitled Elementary Sciece Curriculum Development.

PROCEDURES

The posttest only control group design was used for this study. The following instruments were administered in April 1984:

1. Preferences and Understandings - Student Version, adapted by Yager and Bonnstetter (1984) from NAEP (1978).
2. Preferences and Understandings - Teacher Version, developed by Kyle, Bonnstetter and Yager (1984) as an analogue to the Student Version.

The Preferences and Understandings - Student Version questionnaire consists of 32 attitudinal items referenced from the 1977 Third Assessment of Science,

part of the National Assessment of Educational Progress (NAEP, 1978). The 1977 assessment of science contained, for the first time, an extensive battery of items assessing the affective domain. These items provide valuable insights regarding:

1. Student perceptions concerning their science teachers.
2. Student perceptions of their science classes and course content.
3. Student perceptions of what it would be like being a scientist.

The questionnaire also includes eight common scientific terms which were a part of the 1977 Third Assessment of Science. The questionnaire is not designed to yield a cumulative score. Thus, frequency responses are reported for each item. Chi-square values are also reported in order to assess the relationship between inquiry-oriented, process-approach science and student preferences and understandings of science.

The Preferences and Understandings - Teacher Version was developed as an analogue to the Student Version in order to assess:

1. Teacher perceptions regarding science as a subject.
2. Teacher perceptions of their science teachers.
3. Teacher perceptions of their previous science courses.
4. Teacher perceptions of what it would be like being a scientist.

The Preferences and Understandings - Teacher Version was distributed to all K-6 teachers who were teaching SCIIS during the 1983-84 academic year and to a random sample of 10 teachers at each grade level (K-6) who would be teaching SCIIS during the second year of the implementation project (1984-85). Of the 117 teacher questionnaires distributed, 109 were returned for a response rate of 93.2%. Due to the exceptionally high response to the initial survey, there was no attempt to contact non-respondents.

Two teachers in both SCIIS and non-SCIIS classes in grades 2-6 were randomly selected (from among the teachers in the teacher sample) to administer the Preferences and Understandings - Student Version to their classes. All teachers selected to administer the student questionnaires did so. The student sample is comprised of 228 SCIIS students (54% male and 46% female) and 228 non-SCIIS students (52% male and 48% female).

FINDINGS

The data reported in Tables I-IV indicate that students have a preference for inquiry-oriented, process-approach science. Twenty-seven of the forty items, indicating differences in SCIIS versus non-SCIIS student preferences and understandings of science, yield statistically significant results at the hypothesized level of significance (0.05).

As the number of significance tests increases, however, so does the probability of finding one or more significant results. Lindman (1974) reports a relationship for determining the probability of obtaining a statistically significant result even though all null hypotheses are true:

$$P = 1 - (1 - \text{alpha})^{r}$$

where r = the number of significant tests. Thus, for this investigation, one can see that there is an 87% chance of obtaining one or more significant results even though all 40 null hypotheses are true. That probability is reduced to 33% for alpha = 0.01 and 3.9% for alpha = 0.001. For reporting purposes, in order to allow the reader to formulate personal interpretations of the data, all three significance levels are cited. It is certainly worth noting that 15 of the 40 student preference and understanding items are significant at the alpha = 0.001 level of confidence.

The data also were analyzed by student gender. The non-SCIIS by sex analysis reveals significant differences for six items. A significantly greater percentage of males chose science as either their first or second favorite subject ($p = 0.001$), while a significantly greater percentage of females chose science as their least favorite subject ($p = 0.008$). Additionally, female students in non-SCIIS classes were: less likely to feel as though their teachers liked for them to ask questions ($p = 0.04$); less likely to feel successful through their experiences in science ($p = 0.028$); and, less likely to find their study of science to be useful ($p = 0.016$). These results contrast with students in SCIIS classes where the only significant gender finding is among student preferences for the "kind" of science they like best ($p = 0.012$). While male and female SCIIS students like life science equally well, females indicate a preference for physical science and males tend to prefer earth science.

Finally, SCIIS and non-SCIIS teachers expressed similar attitudes toward science and scientists. Only one significant attitudinal finding was noted, non-SCIIS teachers are more likely to feel that being a scientist would make them feel important ($p = 0.001$).

CONCLUSION

The data overwhelmingly support the fact that students in inquiry-oriented, process-approach science classes have greatly enhanced attitudes toward science and scientists when compared to students in "traditional" textbook-oriented science classes. Forty-three percent of the SCIIS students chose science as their first or second favorite subject. Only 21 percent of the non-SCIIS students made such claims. This dichotomy is further dramatized by the fact that only 7 percent of the SCIIS students cite science as their least favorite subject compared to 18 percent of the non-SCIIS students.

In addition to SCIIS students being more likely to choose science as either their first or second favorite subject in school:

1. Over 75 percent of SCIIS students find science to be fun, exciting, and interesting while fostering a feeling of curiosity. On the other hand, over 50 percent of non-SCIIS students find science to be boring; 33 percent indicate that science makes them feel uncomfortable; and, less than 25 percent indicate that science is fun or fosters a feeling of success.
2. SCIIS students wish that they had more time for science and more "kinds" of science offerings.
3. SCIIS students realize that their science teachers value a high frequency of questions, that their questions are valued, and that questioning is important in science.
4. SCIIS students realize that through their inquiries they develop a feeling of successfulness.
5. SCIIS students feel that science is useful both in their daily lives and in the future; they realize that in addition to gaining knowledge, that being curious and inquisitive are important aspects of science.
6. SCIIS classes enhance the attitudes of females toward science and their science classes.

It is an exceptionally positive sign to observe such drastic attitudinal differences between SCIIS and non-SCIIS students since both SCIIS and non-SCIIS teachers hold similar preferences and images of science and scientists. Approximately 75 percent of all SCIIS (N=45) and non-SCIIS (N=64) teachers indicated that Language Arts was either their first or second favorite subject while they were in school. Less than 15 percent of the teachers indicated

similar preferences for science. Over 25 percent of the teachers sampled indicated that science was their least favorite subject. Both SCIIS and non-SCIIS teachers found their previous science classes to be dull, uninteresting, lacking in excitement, and boring, while only mildly fostering a sense of curiosity. The nature of process-approach science apparently allows SCIIS teachers to portray a much more positive image of science and scientists. Perhaps even more important is the fact that through such science experiences female students may be provided, for the first time, with a positive role model.

It should be apparent then, that the nature of the science taught does affect student attitudes toward science. Teachers are able to portray an image of science that is fun, exciting, and interesting while fostering a sense of curiosity. The nature of process-approach science allows teachers to convey a positive and exciting image of science and scientists. Thus, SCIIS teachers are successfully presenting science in a manner which is positively enhancing student attitudes toward science

The data indicate that students prefer a process-approach science that more closely matches real science versus the traditional textbook-oriented science that more closely resembles the Language Arts. Research also documents that students exposed to inquiry-oriented, process-approach science perform better on measures of general science achievement, process skills, analytic skills and related skills such as language arts and mathematics (Shymansky, Kyle and Alport, 1983).

If we are to meet the challenge of the 1980's and beyond, of producing a scientifically literate citizenry, student attitudes toward science must be positively affected through their school science experiences. High levels of interest, excitement, and curiosity must be created and maintained. The SCIIS

program is doing just that! The SCIIS program is generating up to three times the interest, as well as a sense of fun and excitement, all while enhancing the students' feelings of success.

IMPLICATIONS FOR INSERVICE AND PRE-SERVICE EDUCATION

Just as the key teachers of exemplary programs were more likely to find their inservice useful (Bonnstetter, Penick, and Yager, 1983), the SCIIS teachers also were more positive toward inservice education. By examining the type of inservice experience found in exemplary programs, several characteristics were consistently identified:

1. A longitudinal plan for implementation must be identified. The traditional "one shot approach" is not effective.
2. Strong administrative support is imperative -- in terms of time as well as a fiscal commitment.
3. A local subject matter specialist in a central role facilitates communication and ensures program continuity.
4. An atmosphere of personal involvement in "doing" key components of the new curriculum is necessary during the inservice. Simply discussing the curricular changes will not effect change in the classroom. Teachers must feel a sense of "ownership" to the curriculum and must realize that their implementation efforts are valued by their administrators.

These same characteristics are present in the Richardson Independent School District plan. They started and continue to use an on-going assessment of teacher, student, and program needs to provide the focus for future inservice programs, As a result of this assessment, the SCIIS inservice program involves teachers and building principals "doing" many of the student activities. At the

same time this allows the staff the opportunity to model appropriate questioning skills and demonstrate program integration. This approach also enables teachers to update content knowledge and concept comprehension. An inservice program following this procedure has a much better chance of effecting positive curricular changes.

Pre-service teacher preparation programs could greatly benefit from many of these suggestions. We need to provide more background in science (but not just science). Prospective teachers need to experience more science as inquiry and less didactic, passive lectures followed by confirmatory labs. They need to see science in action and experience science themselves. Instructors in preservice science teacher preparation programs need to model the same behaviors they expect their students to demonstrate in classrooms. Lecturing about inquiry will not provide prospective teachers with experiences conducive to their implementating effective instructional strategies in the future. Pre-service and inservice teachers should also develop skills in cooperative curriculum development in order to ensure program continuity. Teachers must know how to work with administrators and gain their support, respect, and encouragement. Cooperative working behaviors should be established with parents, community leaders, higher education contacts, and local business and industry in order to ensure total commitment to the program.

The result of such efforts in both inservice and pre-service preparation could play a significant role in altering students attitudes toward science, as well as their understanding and knowledge of science. For many years science educators have been highly critical of the nature of elementary and secondary school science. The decision to provide today's students with the skills to function in a scientific and technological society is ours. We know what is effective -- we must begin to use that knowledge to articulate a sound science education curriculum for all students.

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Table I

Student Perceptions Concerning Their Science Teachers:
Percentage of Students Responding Positively

Item	SCIIS N=228	NON-SCIIS N=228	df	X^2
Does your science teacher:				
Ask you questions about science?	94	83	2	23.85***
Like for you to ask questions about science?	58	52	2	1.73
Let you give your own answers?	87	69	2	22.30***
Really like science?	36	25	2	6.81*
Make studying science exciting?	73	46	2	32.27***
Know a lot about science?	43	65	2	23.34***
Admit to not knowing answers to your Q?	72	55	2	14.22***

*** Significant at the 0.001 level.
** Significant at the 0.01 level.
* Significant at the 0.05 level.

TABLE II

Student Perceptions of Their Science Classes and Course Content:
Percentage of Student Responding Positively

Item	SCIIS N=228	NON-SCIIS N=228	df	X^2
Science is my:				
Favorite subject in school	17	7	6	15.96*
Second favorite subject in school	26	14	6	17.81*
Least favorite subject in school	7	18	6	20.30**
Science courses/content:				
Know they are taking science	98	87	2	19.44***
Wish they had more time for science	62	32	2	49.47***
Wish they had more "kinds" of science	55	43	2	11.31**
The science I learn is useful in my daily life	66	67	2	0.11
Knowing a lot about science will be useful in the future	82	75	2	4.30
The science I study is generally useful	70	58	2	8.00*
Prefer life science to Physical/earth science	71	45	2	32.61***

TABLE II (continued)

Item	SCIIS N=228	NON-SCIIS N=228	df	X^2
What is the most important part of science?				
a. Knowing about your world	28	42		
b. Thinking through problems	9	8		
c. Being curious and exploring	31	2	4	10.41*
d. Explaining things you see	8	6		
e. Testing your ideas	23	22		
Is it important to plan experiments to test ideas?	78	76	2	0.33
Science is:				
Fun	85	53	2	60.13***
Interesting	88	64	2	36.24***
Exciting	70	44	2	33.06***
Boring	13	35	2	32.65***
Science Makes me Feel:				
Uncomfortable	11	24	2	14.30***
Successful	59	45	2	12.23**
Curious	76	56	2	21.65***

*** Significant at the 0.001 level.
** Significant at the 0.01 level.
* Significant at the 0.05 level.

TABLE III

Student Perceptions of What it Would Be Like
Being a Scientist: Percentage of Students Responding Positively

Item	SCIIS N=228	NON-SCIIS N=228	df	X^2
Being a scientist would be:				
Fun	49	39	2	8.09*
Make me rich	32	24	2	3.63
A lot of work	86	88	2	1.88
Boring	23	29	2	1.91
Make me feel important	61	56	2	1.24
Make me feel lonely	10	16	2	2.74

*** Significant at the 0.001 level.
** Significant at the 0.01 level.
* Significant at the 0.05 level.

TABLE IV

Student Responses to Common Scientific Terms:
Percentage of Students Responding Correctly

Term	SCIIS N=228	NON-SCIIS N=228	df	X^2
Volume	28	19	5	11.02*
Organism	52	18	5	69.24***
Motion	38	31	5	12.22*
Energy	43	30	5	12.06*
Molecule	24	21	5	6.98
Cell	44	42	5	3.50
Enzyme	6	5	5	1.58
Fossil	36	37	5	2.41

*** Significant at the 0.001 level.
** Significant at the 0.01 level.
* Significant at the 0.05 level.